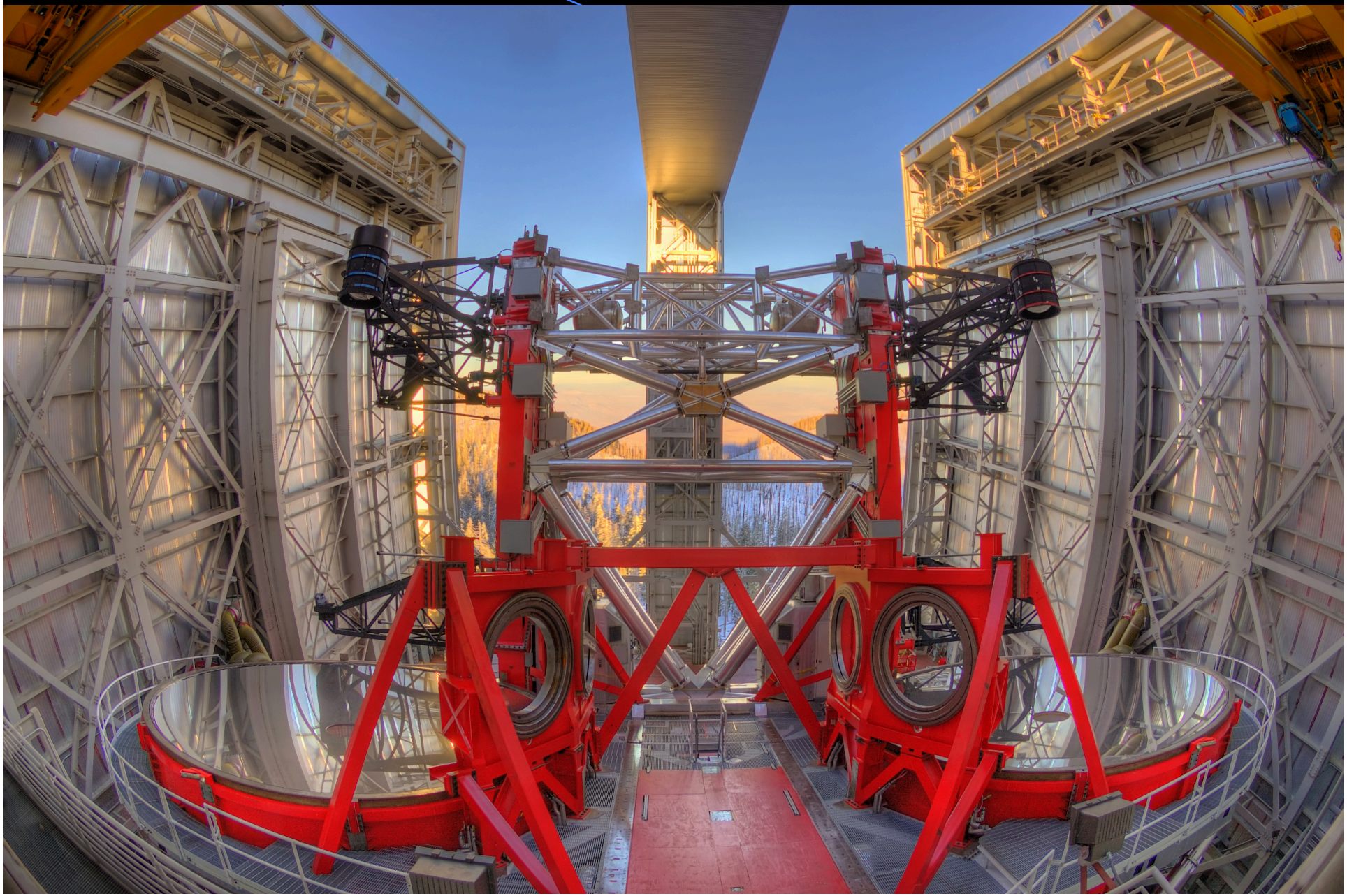
Importance of Dark Skies for Arizona Astronomy

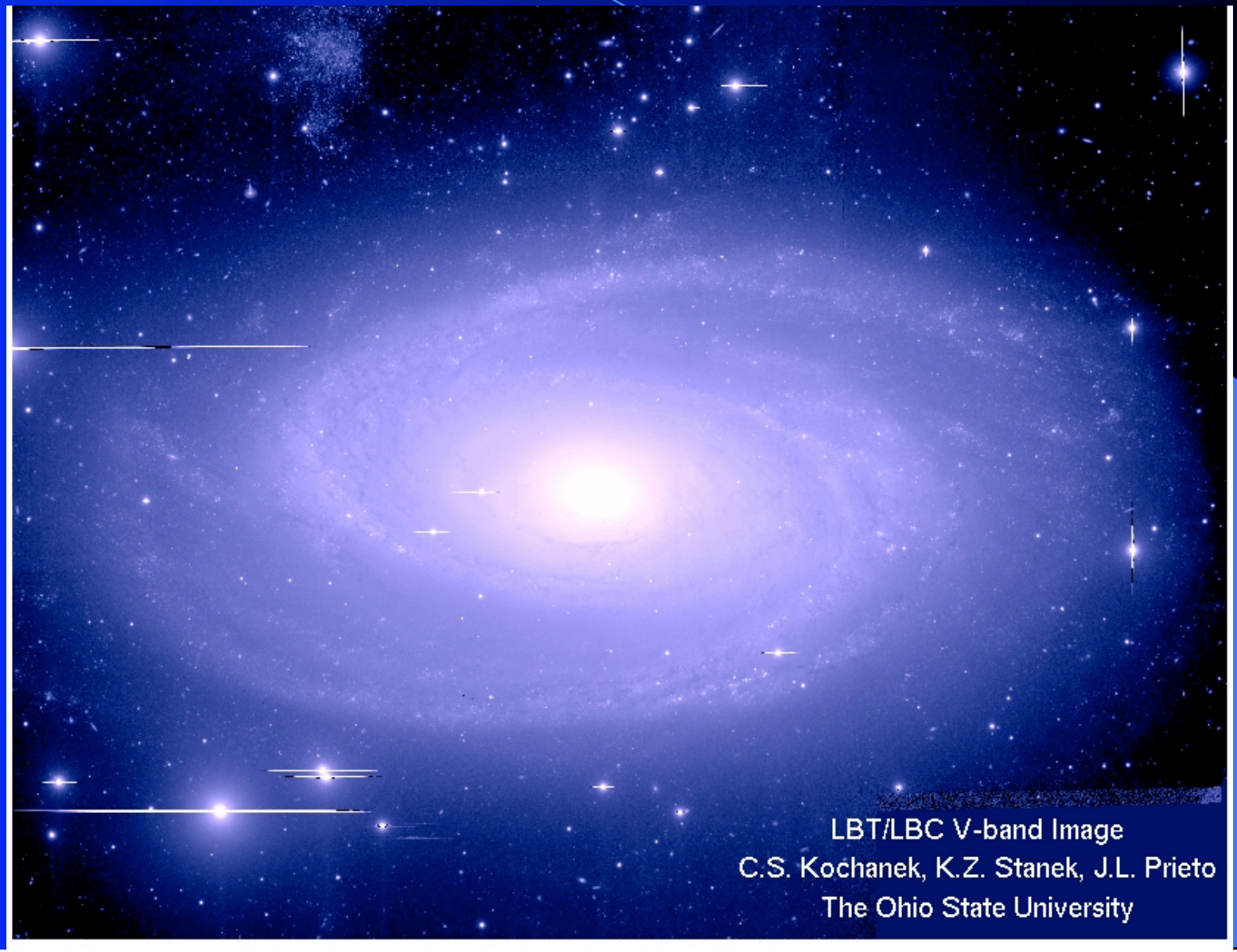
February, 2011

Richard Green, Director, Large Binocular Telescope

The World's Largest Telescope is in SE Arizona



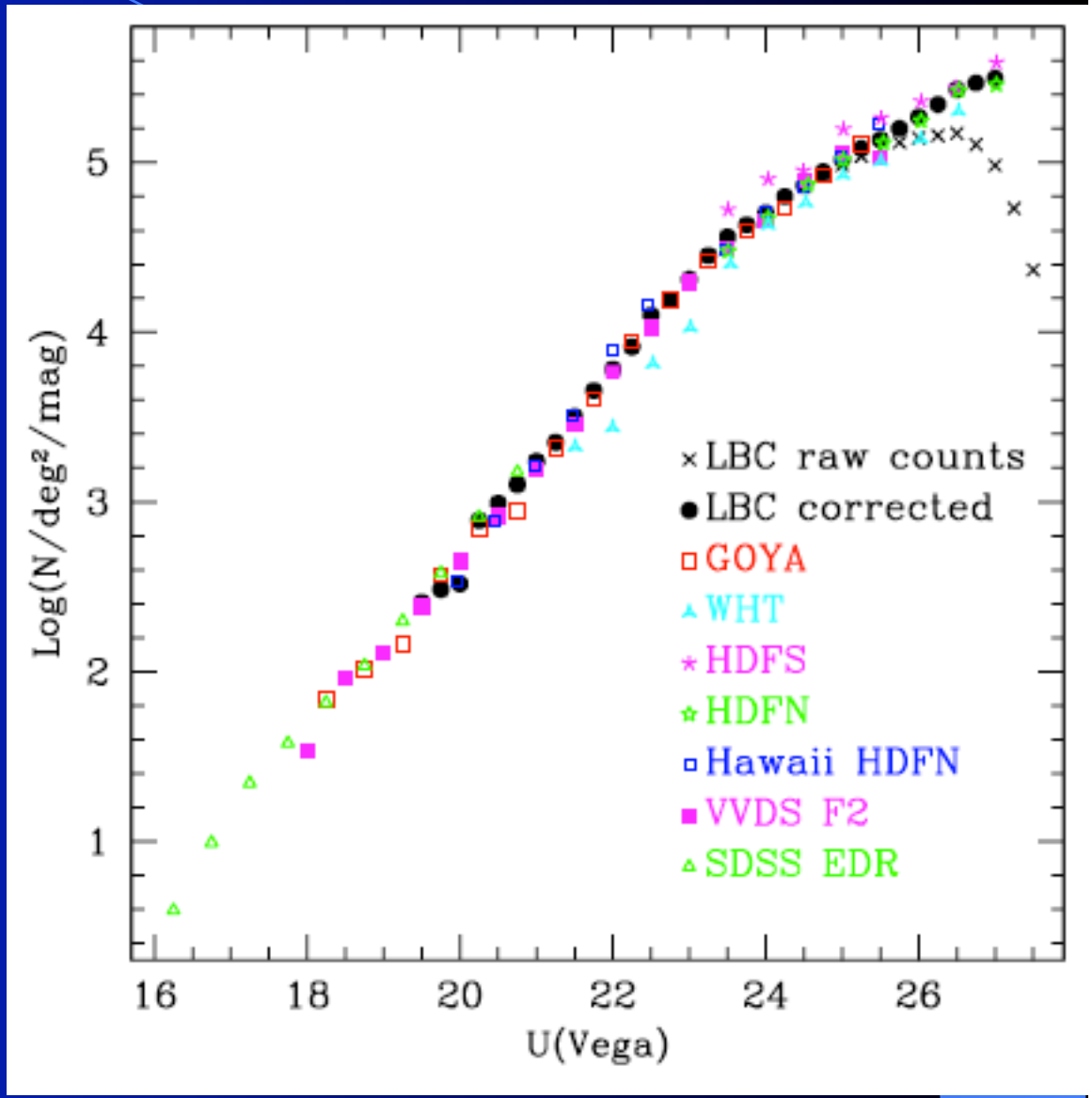
Telescopes are known for stunning images of “bright objects” (M 81 – 12 million light-yrs away)



LBT Takes Images as Deep as Hubble Space Telescope

Wide, Deep UV Galaxy Counts

- Deep images taken by Hubble Space Tel. are in fields named HDF S & N.
- The LBT images record galaxies that are >100 times fainter than the natural glow of the night sky, as deep as HST.
- The science is to study how stars & galaxies formed over cosmic time.
- The limiting sensitivity depends on a dark sky in the ultraviolet and blue.



Astronomy is a State-Wide Enterprise

- Sites marked in blue are professional observatories with large-aperture telescopes.
- Sites particularly impacted by Maricopa County light pollution are Lowell Obs, US Naval Obs, and Discovery Channel Tel near Flagstaff, and LBT + Vatican telescope on Mt. Graham.

Site Protection is a Regional Issue

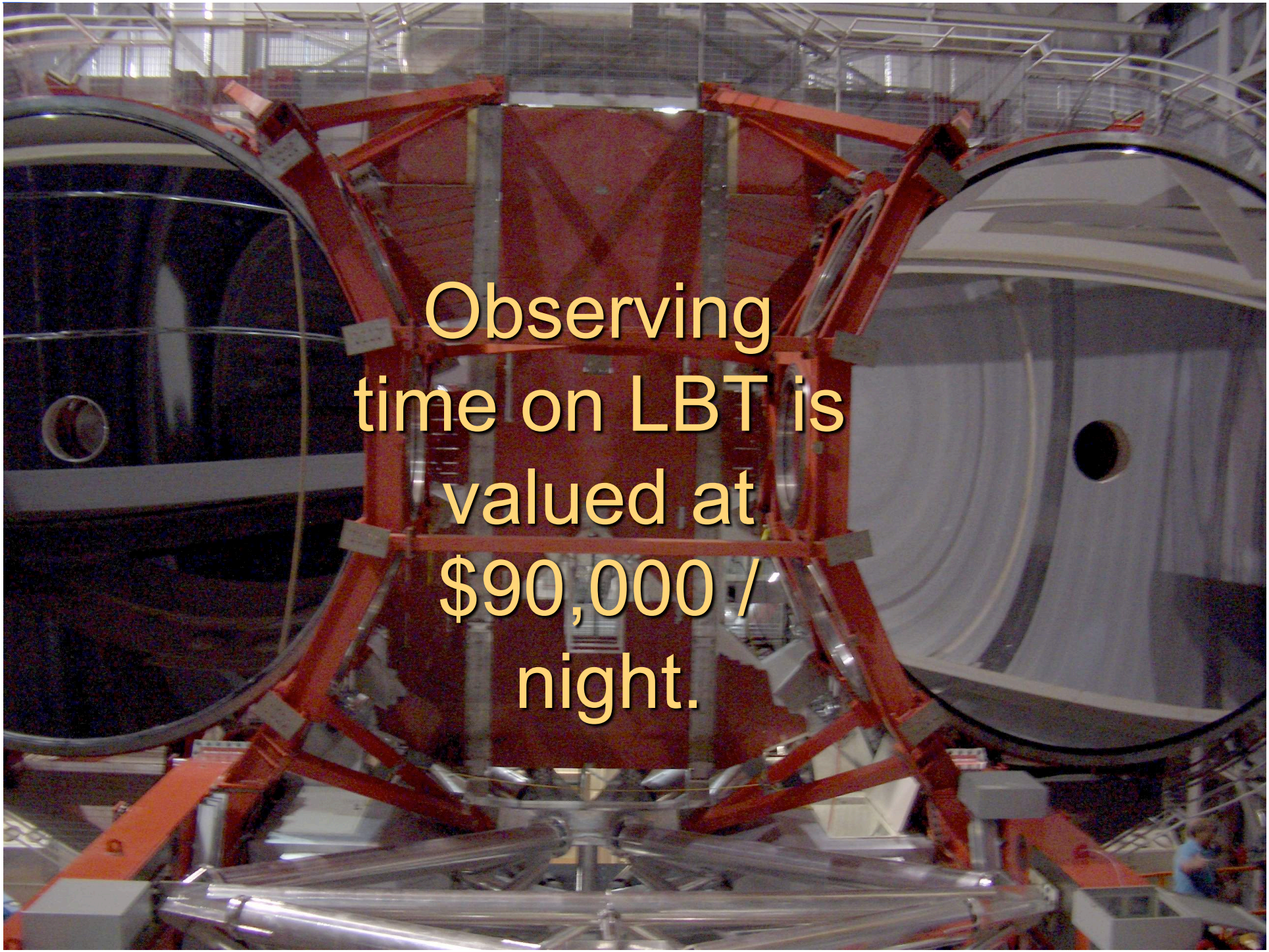
Light Pollution at Mt.Graham from LBT dome March 10 2008

- At Mt. Graham, light domes from metro Tucson (70 miles) and metro Phoenix (130 miles) dominate the western horizon.
- On a clear moonless night, the sky brightness in the west at 45° above the horizon is 10% brighter than in the opposite (dark) direction.
- (Thin clouds increase the light scattered from the cities toward the mountain to 50% excess over dark sky.)

Site Protection is a Regional Issue

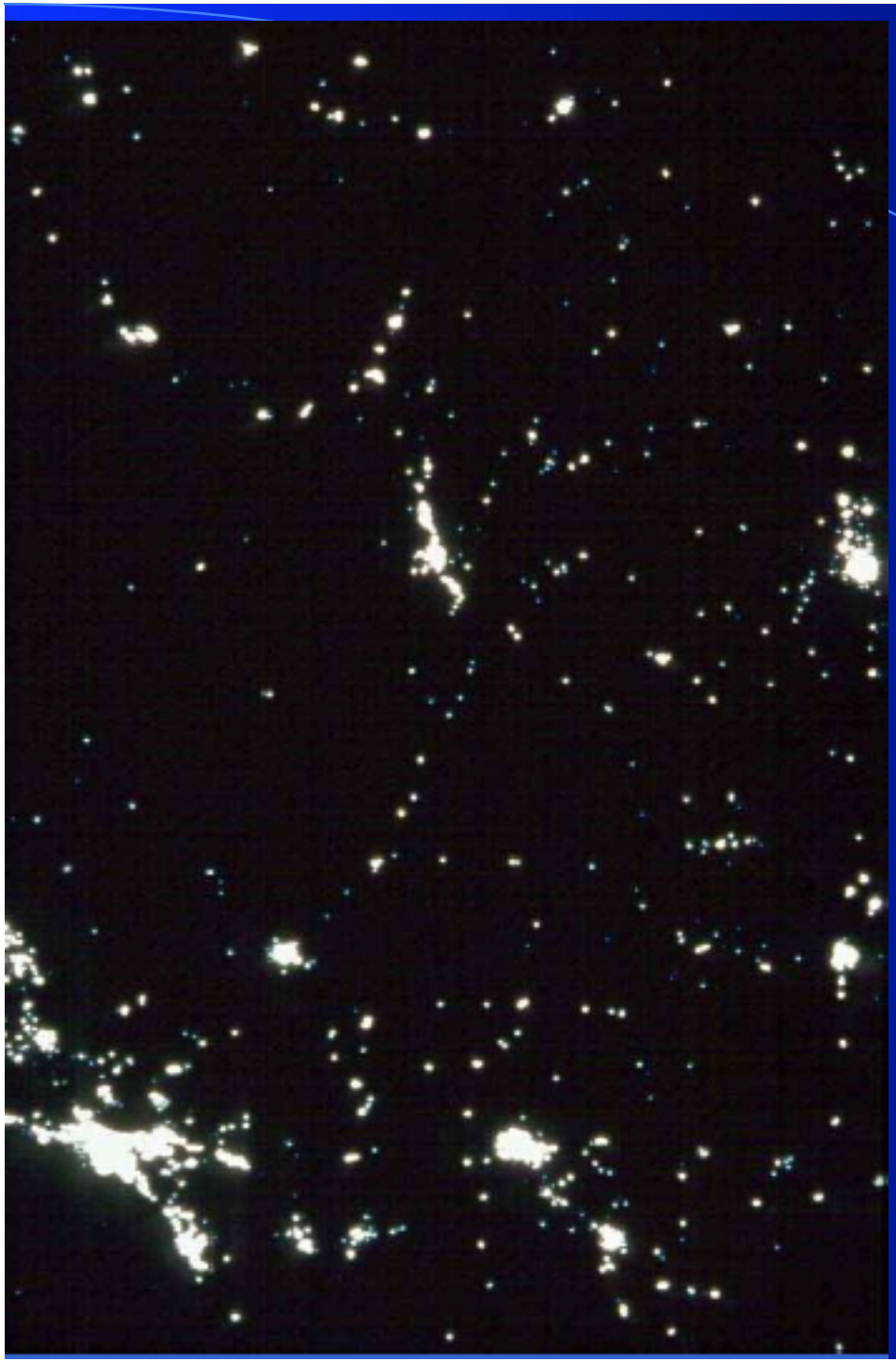
Light Pollution at Mt.Graham from LBT dome March 10 2008

- Physical model of light scattering makes prediction of impact from metro Tucson (70 miles, population 1 million) and metro Phoenix (130 miles, population 4 million).
- Prediction for artificial light addition over natural sky is 0.097 for Tucson metro, 0.083 for Phoenix metro.
- Equal contributions, consistent with measurement (10% each).


Observing
time on LBT is
valued at
$90,000 /
night.

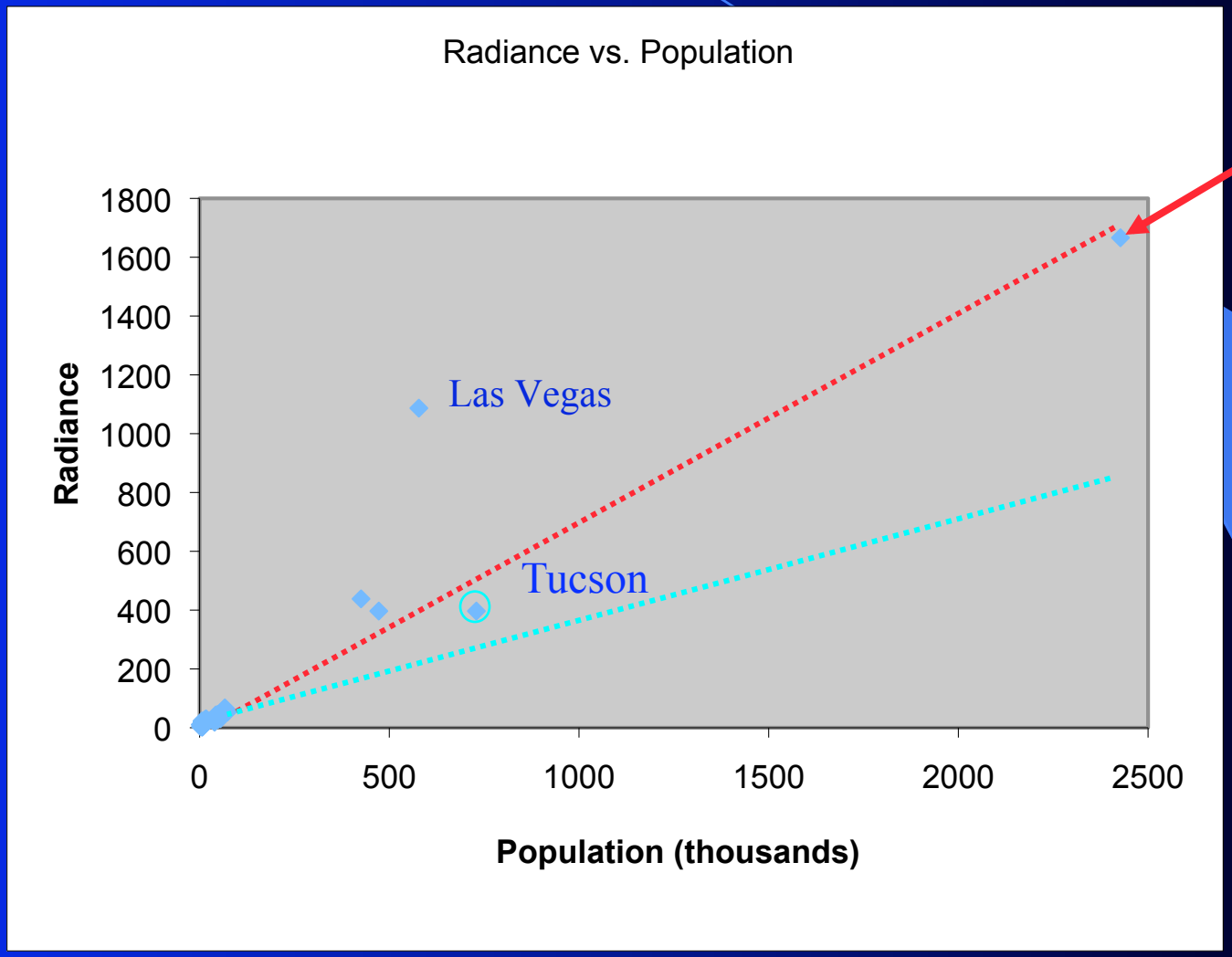
Economic Impact

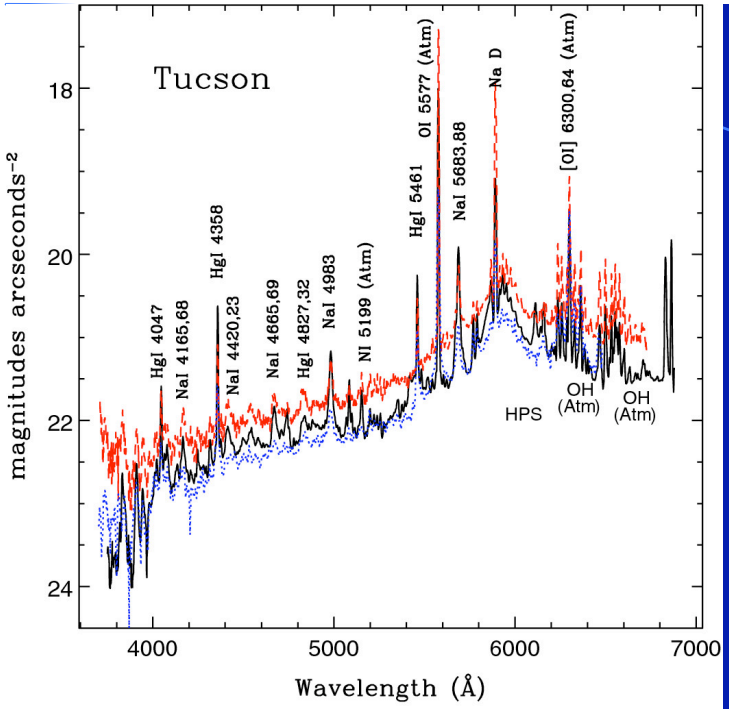
- For a 10% increase over natural sky brightness, 20% more exposure time is needed to record the same level of information about any celestial object fainter than the natural sky glow.
- The light pollution from Maricopa County (and Tucson) already costs the LBT international partners the equivalent of $18,000 per night.
- Equivalently, light pollution from Phoenix (and Tucson) metro degrades the capital value of the facility by ~$40 million.

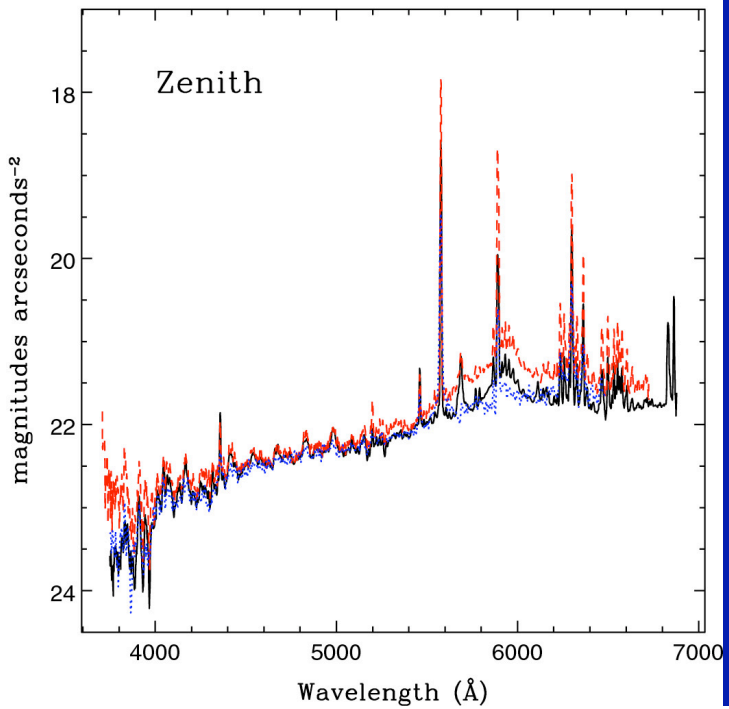


- Satellite view of the Southwest shows uplighting from metro areas.
- C. Luginbuhl found a well-defined relationship between population and scattered light, consistent with the physical model.

SW Urban Population Growth Means Increased Scattered Light







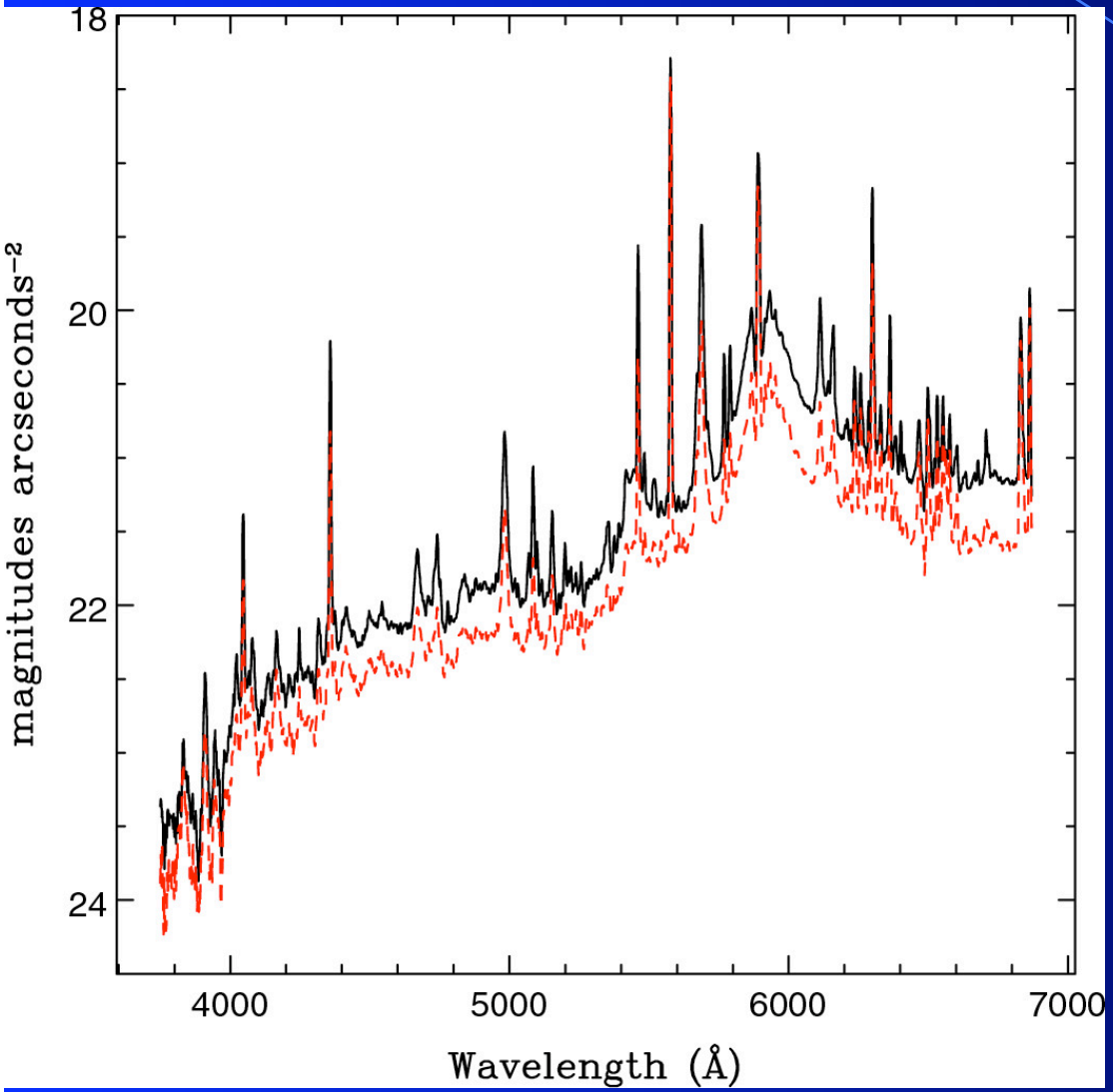
What have we learned from observatories near Tucson?

- Neugent & Massey (PASP, 122, 896, 2010) report on the sky brightness changes at Kitt Peak over 20 years.
- 1988 – blue dotted line
- 1999 – red dashed line
- 2009 – black solid line

- HPS = high-pressure sodium

- Corrected for changes in natural sky brightness from solar activity, zenith sky has 10% added from city lights, and the direction toward Tucson has 30% additional, compared to 20 years ago.

What have we learned from observatories near Tucson?



- More importantly, there has been essentially no change at zenith in the last 10 years, while the population of metro Tucson has continued to grow rapidly.
- The plot at left shows the sky brightness toward Tucson at 9:20 PM (black) vs. 3:20 AM (red), clearly demonstrating less scattered light when outdoor lighting is reduced.

Conclusions

- The goal of promoting intelligent lighting design and use is to make the growth of scattered light from Arizona urban areas far slower than the growth of population.
- As shown in the following presentations, the effective means of doing so are
  - Prevention of direct uplighting.
  - Assuring that new luminaires are full cut-off fixtures.
  - Observing the energy-conserving practice of turning off the illumination when there is no need or no market, i.e., curfew.
  - Controlling the color temperature of the lamps or LEDs to avoid wasting energy by radiating colors invisible or safety-inhibiting to the eye.
  - Matching the level of illumination to that appropriate for the zone in which it is applied, i.e., lumens caps.